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REPORT OF WIND-TUNNEL TEST OF DH-4B MODEL

1. With $7\frac{1}{2}$-inch positive stagger } Full scale
2. With 2-inch negative stagger } Full scale

(AIRPLANE SECTION, S. & A. BRANCH)

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Prepared by Lieut. C. L. Morse, A. S.
Engineering Division, Air Service, McCook Field
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REPORT OF WIND TUNNEL TEST OF DH-4B MODEL.

1. With $7\frac{1}{2}$-inch positive stagger } Full scale.
2. With 2-inch negative stagger }

A 1/24 scale model of the DH-4B airplane, with a 300 Wright engine, was constructed at McCook Field. It was tested at the Massachusetts Institute of Technology for lift drag, L/L and moments about the center of gravity for various angles of incidence and tail settings for both positive and negative stagger. Two tests were run, the first with $7\frac{1}{2}$-inch positive stagger (for the full scale airplane) and the second with 2-inch negative stagger (also for the full scale airplane).

OBJECT.

The object of the test, with positive stagger, was to obtain the correct tail setting for balance of this airplane, as it had been very tail heavy.

The object of the test, with negative stagger, was to obtain the proper balance of the airplane for additional weight due to machine guns.

RESULTS.

The forces are almost exactly equal for both positive and negative stagger, the most marked difference being in the minimum drag, which is about 40 per cent larger with negative stagger than with positive. The lift curves are everywhere alike within the experimental error, and the maximum L/D is absolutely identical in the two cases.

In examining the balance, the moments have been plotted with reference to the original center of gravity. The airplane then trims at $-0.1°$ with a tail setting of $-1°$. With the same tail setting and the normal positive stagger the trimming angle was $+8°$.

To secure perfect balance with the negative stagger and the same tail setting at the original trimming angle of $+8°$, the center of gravity would have to be moved back .26 inches on the model, the equivalent of 6.2 inches on the full sized airplane. This is more than half the change in stagger.

For the same degree of stability the center of gravity must be much farther forward on the mean chord for negative stagger than for positive.

DISCUSSION.

The model was supported on an end spindle in the upper wing. The runs for lift and drag were made at 30 miles per hour throughout, but when moments were taken the vibration was so great that the speed had to be reduced to 20 miles per hour at all angles beyond, but not including 14°.

The model had a positive stagger of $7\frac{1}{2}$ inches (full scale) and the wing section was the R. A. F. 15.

The tail plane was set at $-1°$ to the upper wing.

The lift curve shows the characteristic, so frequently observed in tests of complete models, of gradual increase to a maximum at a very high angle, $+25°$ in this case. The maximum L/D is good for a machine of this type, and the ratio of the maximum lift to minimum drag is 19.6. The maintenance, over a large range of a very high lift, is probably due in this case to biplane effect primarily, the lift of the lower wing increasing while that of the upper decreases up to an angle of about 40°.

The moment curve indicates satisfactory stability down as far as the angle of zero lift. The degree of stability increases, with increase of angle, becoming excessive at angles beyond $+14°$. This is quite at variance with the results of a free flight test on the DH-4, in which the stability was found to be greatest at high speeds, the machine becoming unstable with free controls in the neighborhood of the minimum speed.

A second test was run, using the same model except that it had 2-inch (full scale) negative stagger instead of $7\frac{1}{2}$-inch (full scale) positive stagger. The model was supported exactly as before.

As the primary object of this test was to investigate the effect of the negative stagger on balance, the maximum lift being little affected by stagger, the angle of attack was only carried up to 12°, thus averting the danger of injury to the model by its vibration at large angles.

In order to show more forcibly the effect on stability and balance of a change in stagger, the moment curves for the positive stagger with the original center of gravity and for the negative stagger with the center of gravity moved back six (6) inches (full scale) have been plotted. The airplane balances very nearly under the same conditions for these two cases, the moment curves intersecting at 8°, but the curves are entirely different in form. That for positive stagger has a large negative slope at all positive angles, while the curve for negative stagger is practically horizontal throughout. The effect of positive stagger, even when not accompanied by decalage, in increasing stability is this clearly shown.

For the same degree of stability, the center of gravity must be much farther forward on the mean chord for negative stagger than for positive. It follows, that to make the stability and balance both the same in the two cases, the angle of negative tail setting must be increased as the stagger decreases. The proper allowance for the effect of

stagger can be made automatically if, instead of taking the mean chord midway between the two wings, it be taken much nearer the lower wing. It might be mentioned that the same phenomenon has been noted in free flight testing. (Report No. 96, N. A. C. A.), where a decrease of stagger was found to produce much less favorable effect on stability than had been anticipated from the resultant shift of the center of gravity position on the mean chord.

The characteristics of the DH-4B with both positive and negative stagger are given in the following tables and the results are also plotted, in figures 1-5 inclusive.

Figure 6 is a three-view drawing of the DH-4B model.

TABLE 1.—*Positive Stagger 7½ inches (full scale) Tail Plane −1° to Wing Chord.*

Θ	L	D	L/D	$M_{c.g.}$
−4	−0.220	0.1174	−1.88	+0.29
−2	.052	.0987	+0.53	+ .12
0	.382	.0953	4.01	+ .05
+2	.731	.1064	6.86	+ .09
4	1.020	.1281	7.96	+ .10
6	1.311	.1581	8.30	− .04
8	1.572	.2000	7.86	+ .01
10	1.786	.2651	6.74	− .10
12	1.801	.4121	4.37	+ .03
14	1.833	.5295	3.46	− .70
16	1.874	.6428	2.92	−1.08
18	1.861	.7436	2.51	−1.35
20	1.863	.8333	2.24	−1.56
22	1.905	.9291	....	−1.85
24	....	....	....	....
28	....	....	....	....

Θ=angle chord of wing makes with wind.
L=lift in pounds.
D=drag in pounds.
$M_{c.g.}$=moment about center of gravity in inch-pounds.
Velocity: 30 miles per hour.
Scale: 1/24.
MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *August 9, 1921.*

TABLE 2.—*Positive Stagger 7½ inches (full scale) Tail Plane −1° to Upper Wing.*

Θ	L	D	L/D	$M_{c.g.}$
−4	....	0.114	....	+0.31
−2	+0.04	.100	+0.40	+ .53
0	.32	.096	.3.34	+ .49
+2	.59	.104	5.67	+ .42
4	.815	.122	6.67	+ .32
6	1.055	.142	7.43	+ .21
8	1.32	.168	7.85	+ .07
10	1.56	.210	7.43	− .10
12	1.71	.266	6.42	− .22
14	1.75	.324	5.40	− .41
16	1.75	.370	4.73	− .97
18	1.76	.473	3.72	−1.46
20	1.79	.572	3.13	−1.76
22	1.84	.657	2.80	−2.0
24	1.87	.748	2.50	−2.23
26	1.87	.813	2.30	−2.44
28	1.86	.885	2.10	....

Velocity: 30 miles per hour.
MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *August 27, 1921.*

TABLE 3.—*Negative Stagger 2 inches (full scale).*

Θ	L	D	L/D	Z	$M_{c.g.}$	X
−4	−0.39	0.131	−2.98	−0.31	+0.160	+0.110
−2	− .13	.111	−1.17	− .12	+ .117	.107
0	+ .15	.101	+1.485	+ .14	− .010	.101
+2	0.51	.102	5.00	.51	.146	.084
4	0.784	.116	6.76	.79	.225	.060
6	1.030	.136	7.57	1.04	.285	+ .024
8	1.260	.162	7.77	1.29	.330	− .016
10	1.480	.204	7.25	1.51	.382	− .058
12	1.690	.253	6.68	1.70	.485	− .102

Θ=angle chord makes with wind.
L=lift in pounds.
D=drag in pounds.
$M_{c.g.}$=moment about center of gravity in inch pounds.
X=longitudinal force on model in pounds.
Z=normal force on model in pounds.
Velocity: 30 miles per hour.
MASSACHUSETTS INSTITUTE OF TECHNOLOGY, *September 6, 1921.*

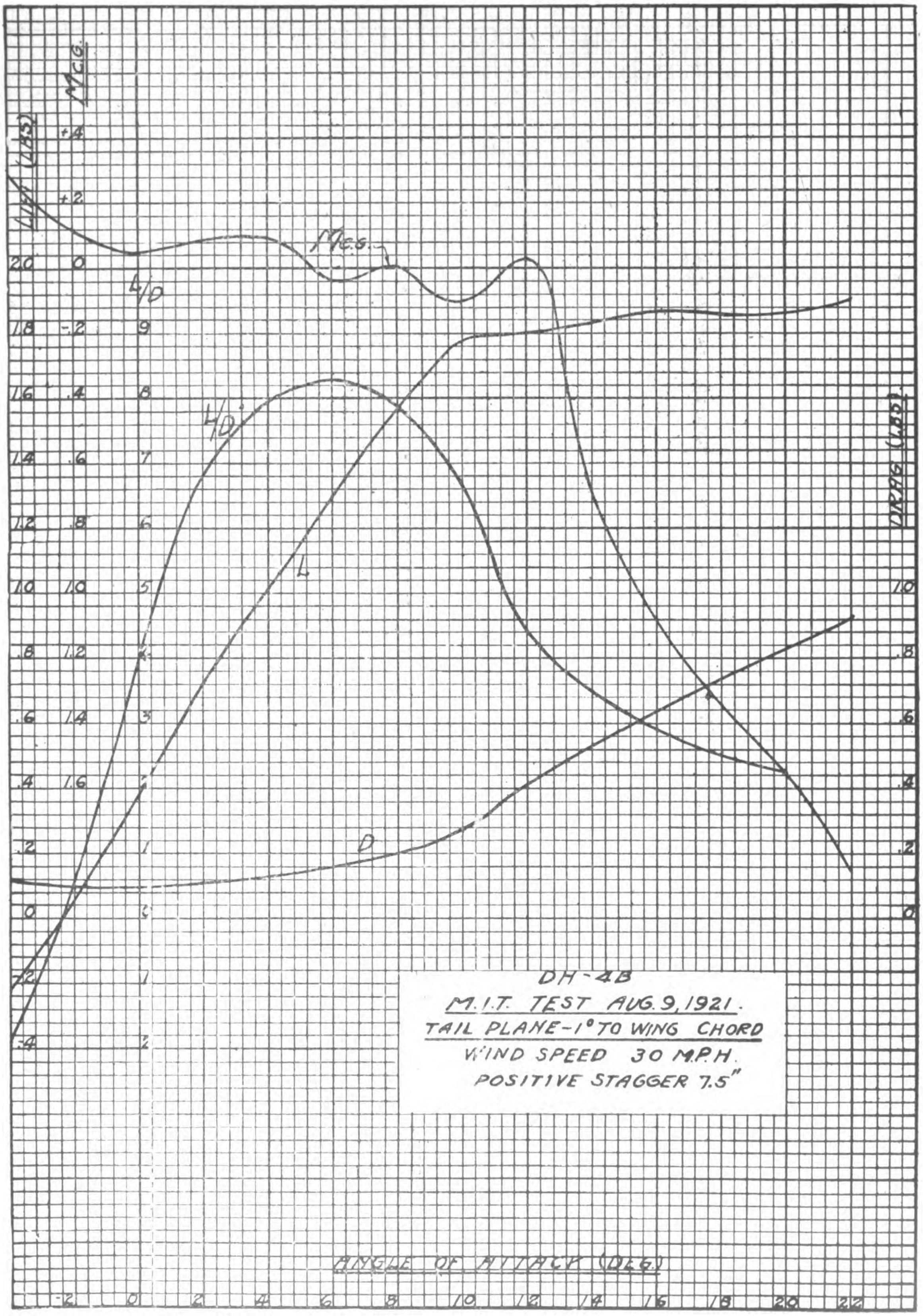
DH-4B
M.I.T. TEST AUG. 9, 1921.
TAIL PLANE -1° TO WING CHORD
WIND SPEED 30 M.P.H.
POSITIVE STAGGER 7.5"
LIFT (LBS)
Mc.G.
DRAG (LBS)
L/D
L
D
Mc.G.
ANGLE OF ATTACK (DEG)

FIGURE 1.

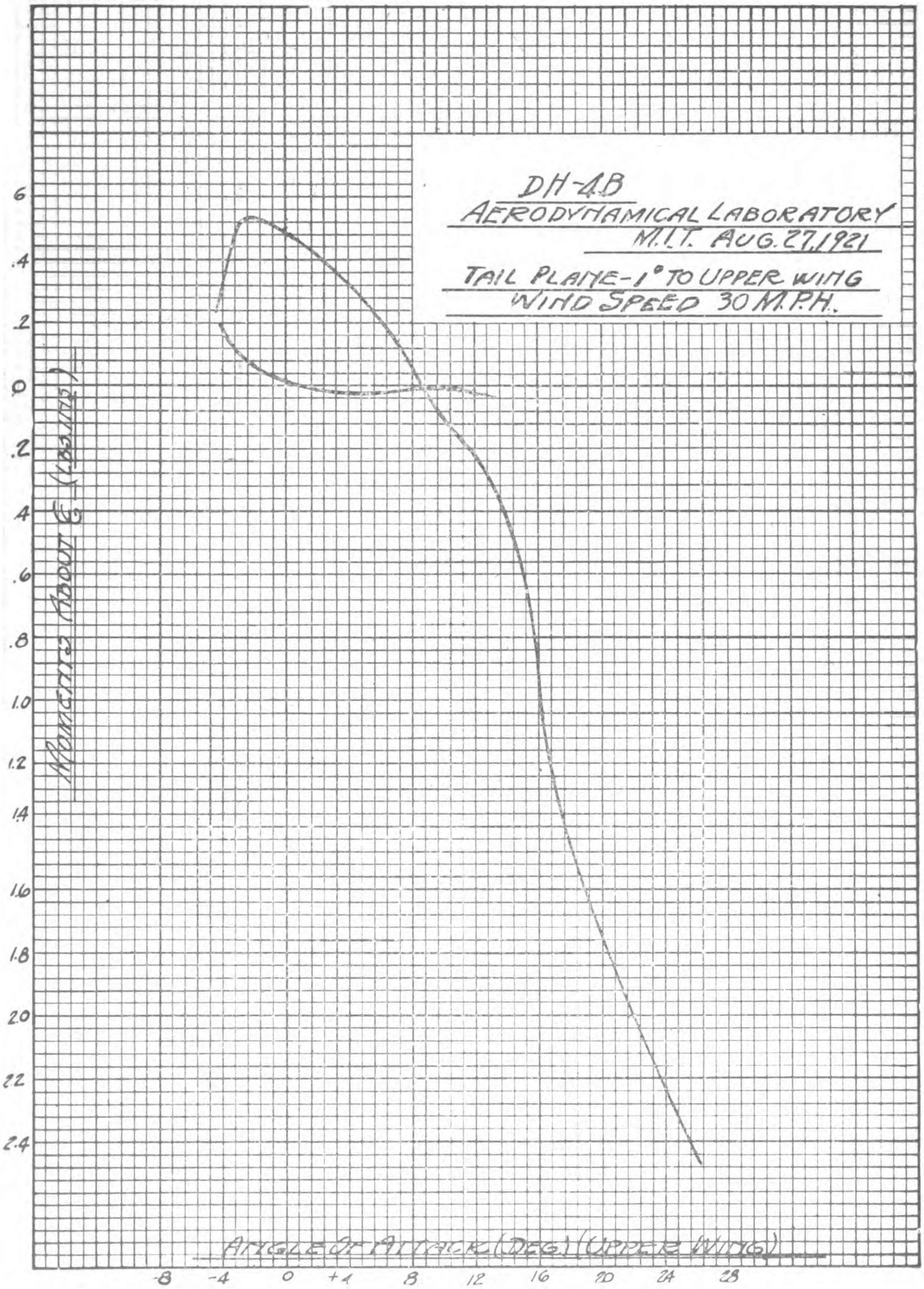
DH-4B
AERODYNAMICAL LABORATORY
M.I.T. AUG. 27, 1921
TAIL PLANE-1° TO UPPER WING
WIND SPEED 30 M.P.H.
MOMENTS ABOUT E (LBS.FT.)
ANGLE OF ATTACK (DEG) (UPPER WING)
.6
.4
.2
0
.2
.4
.6
.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
-8
-4
0
+4
8
12
16
20
24
28

FIG. 2.

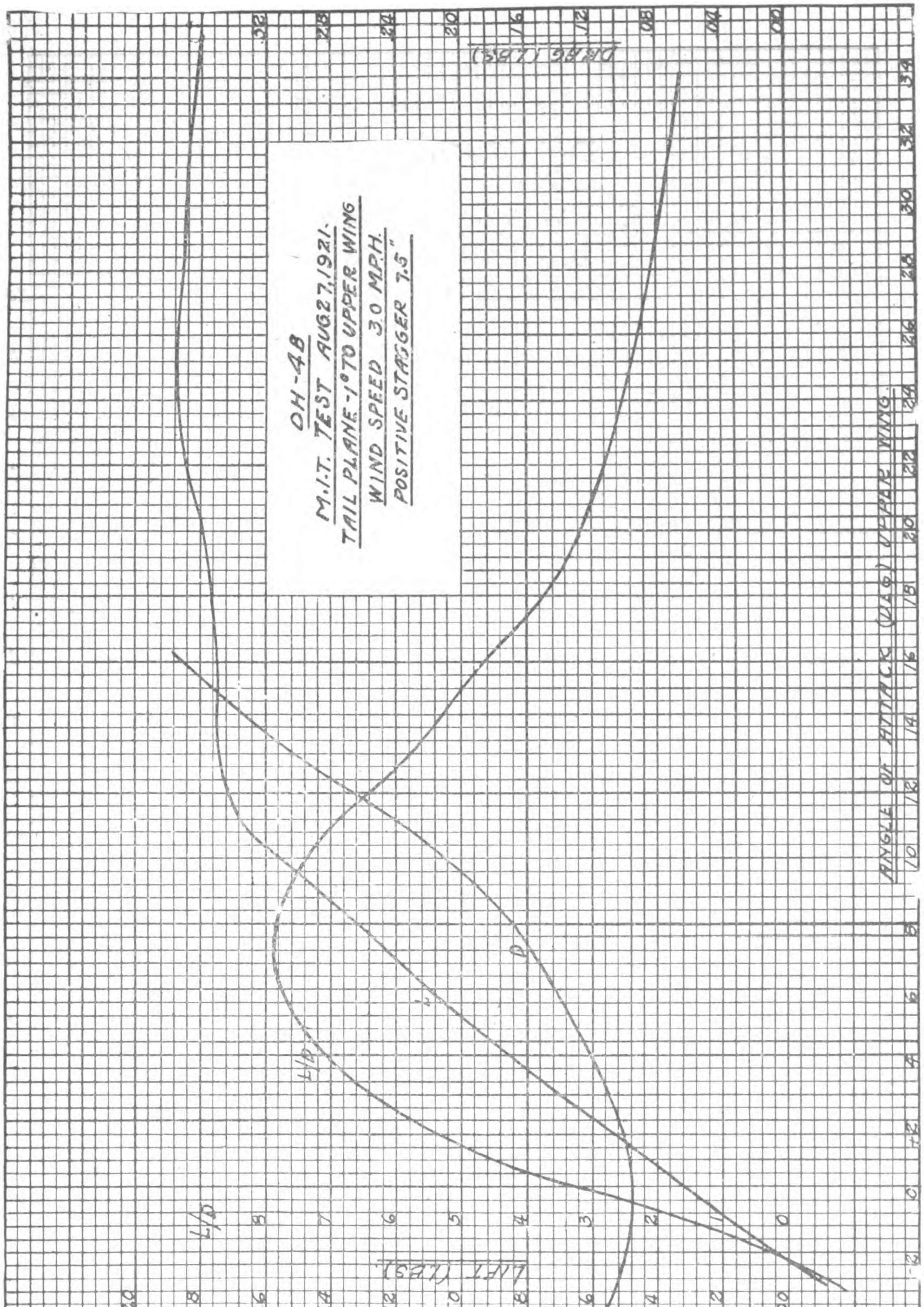
OH-4B
M.I.T. TEST AUG 27, 1921.
TAIL PLANE -1° TO UPPER WING
WIND SPEED 30 M.P.H.
POSITIVE STAGGER 7.5"
DRAG (LBS)
LIFT (LBS)
L/D
ANGLE OF ATTACK (LAG) UPPER WING
L
D

FIG. 3.

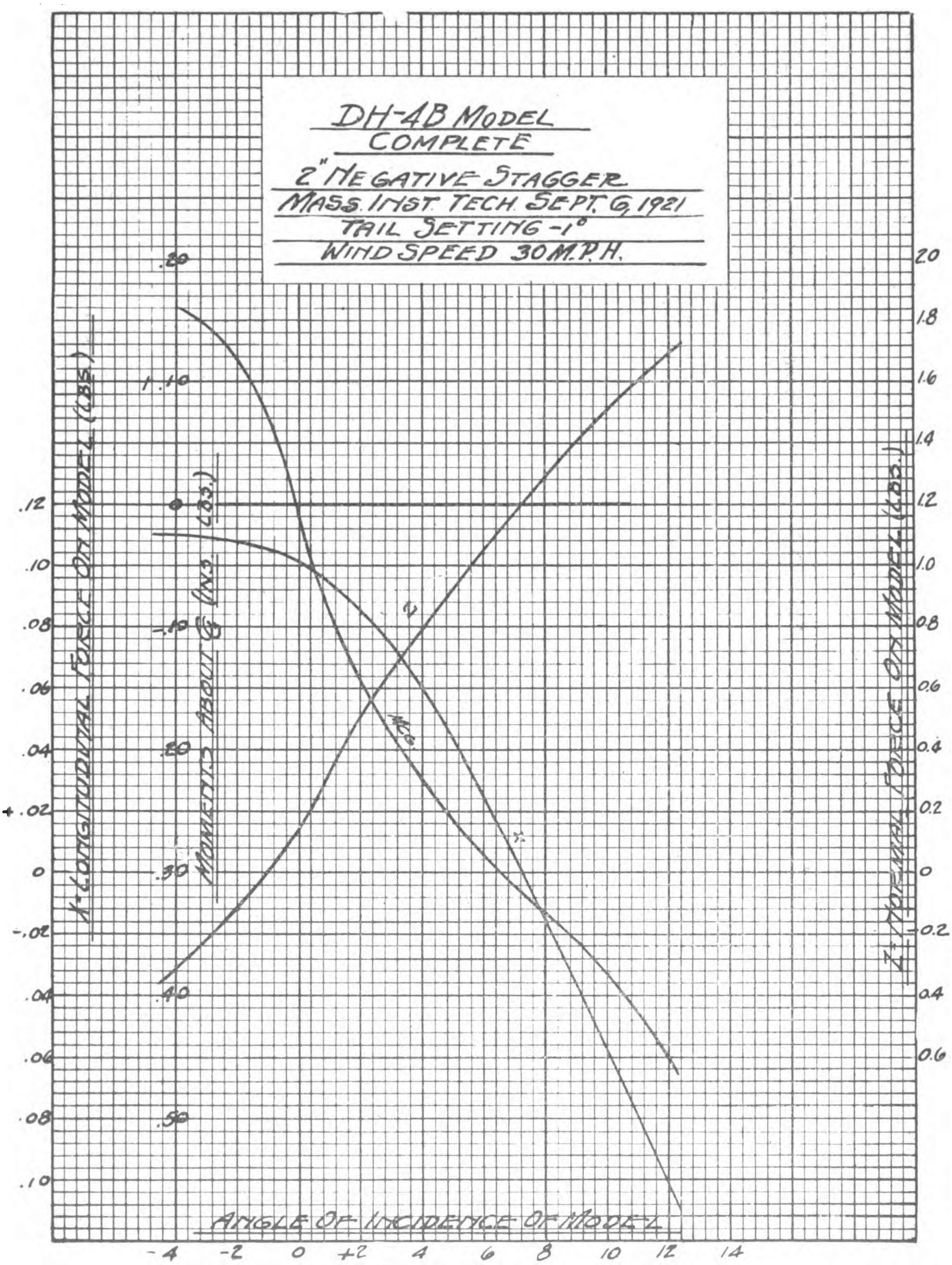
DH-4B MODEL
COMPLETE
2" NEGATIVE STAGGER
MASS. INST. TECH. SEPT. 6, 1921
TAIL SETTING -1°
WIND SPEED 30 M.P.H.
X-LONGITUDINAL FORCE ON MODEL (LBS.)
MOMENTS ABOUT CG (INS LBS.)
Z-NORMAL FORCE ON MODEL (LBS.)
ANGLE OF INCIDENCE OF MODEL
-4
-2
0
+2
4
6
8
10
12
14

FIG. 4.

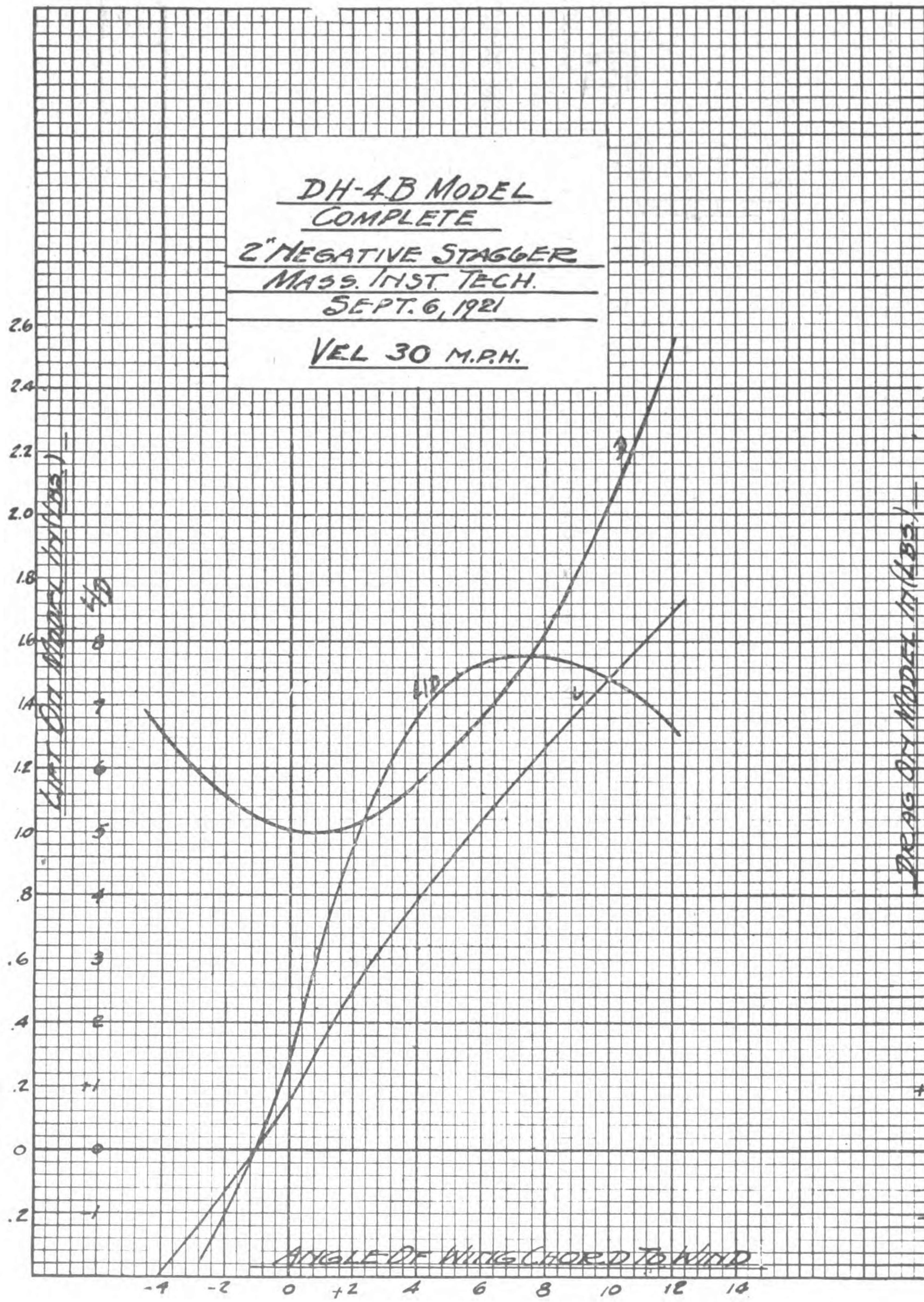
DH-4B MODEL
COMPLETE
2" NEGATIVE STAGGER
MASS. INST. TECH.
SEPT. 6, 1921
VEL 30 M.P.H.
LIFT ON MODEL IN (LBS.)
L/D
DRAG ON MODEL IN (LBS.)
ANGLE OF WING CHORD TO WIND

FIG. 5.

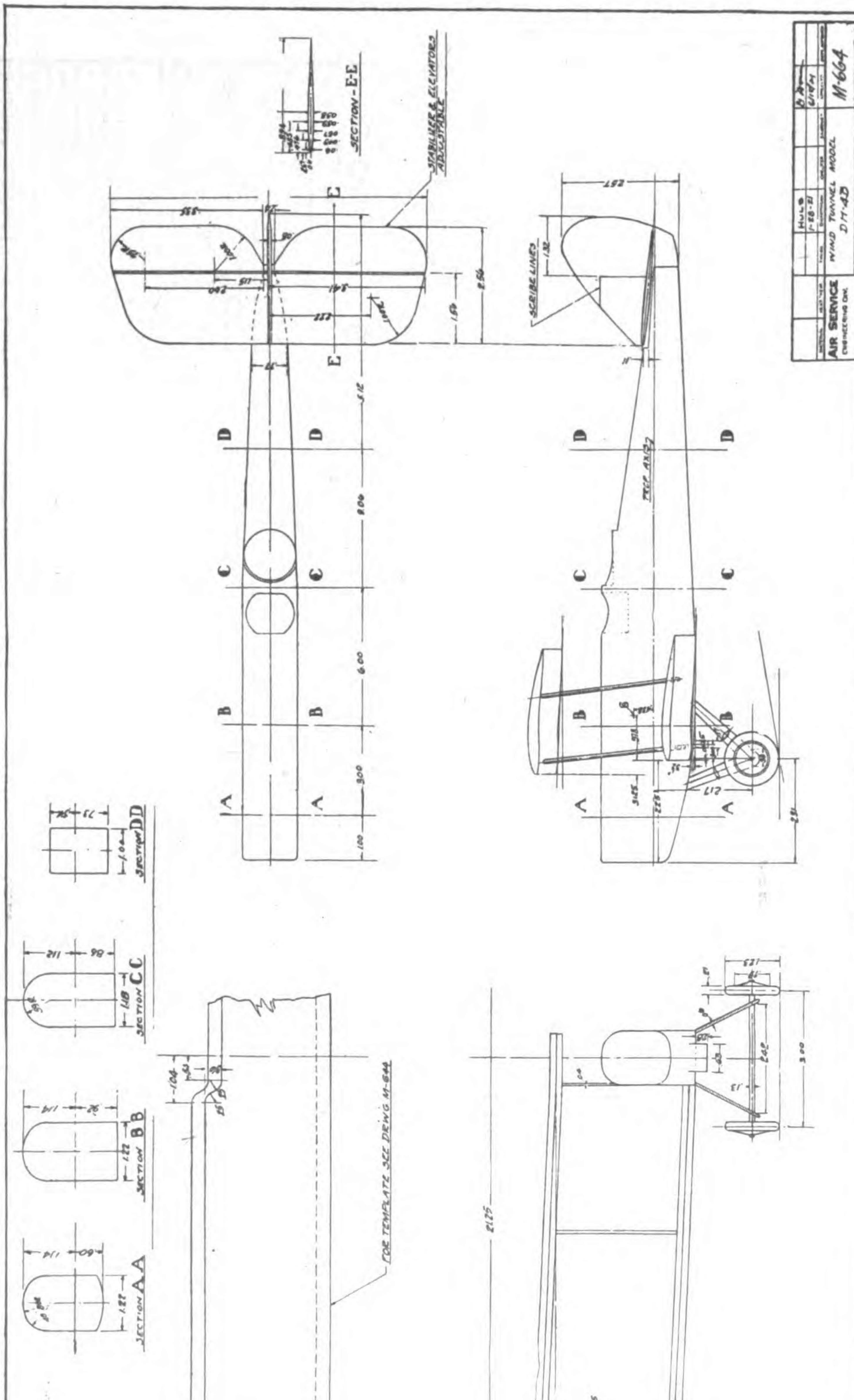
SECTION A A
SECTION B B
SECTION C C
SECTION D D
SECTION - E-E
STABILIZER & ELEVATORS ADJUSTABLE
SCRIBE LINES
FOR TEMPLATE SEE DRWG M-644
AIR SERVICE
ENGINEERING DIV.
WIND TUNNEL MODEL
DH-4B
M-664

FIG. 6.